



# HARDCOATING TECHNOLOGIES

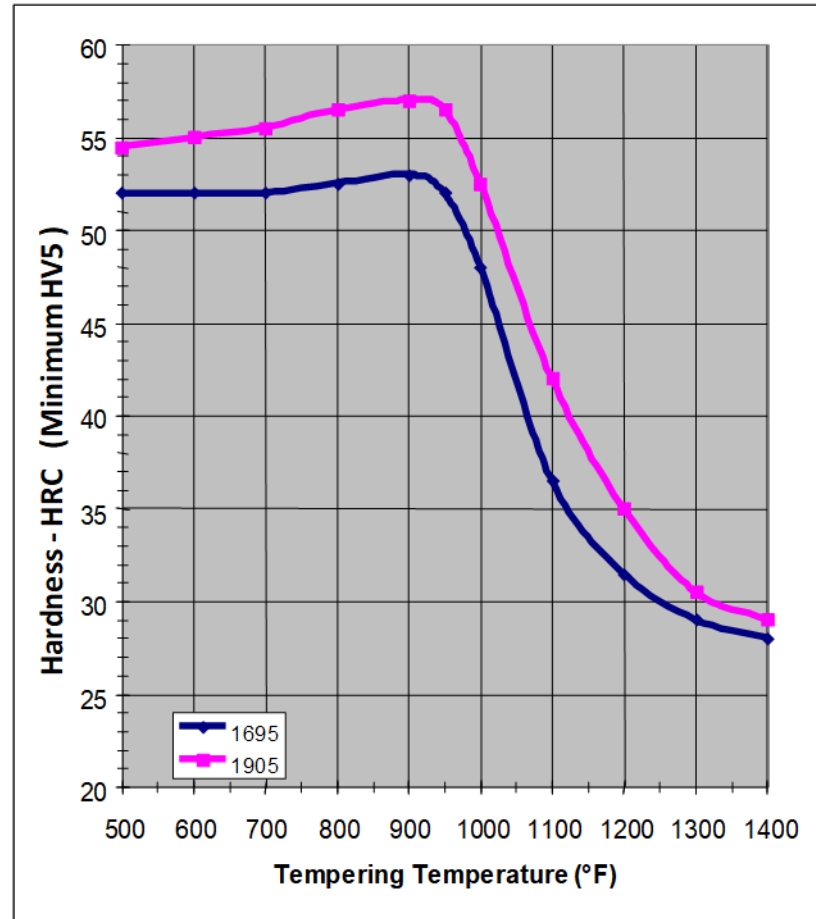


## 440C Martensitic Stainless Steel

Equivalent materials to 440C are:

- AISI 440C
- AMS 5618
- AMS 5630
- AMS 5880
- ASTM A276
- ASTM A314
- ASTM A473
- ASTM A493
- ASTM A580
- DIN 1.4125
- QQ S763
- UNS S44004

### Hardness vs. Tempering Temperature



### Hardness - HRC

Tempering Temperature (°F)	Austenitizing Temperature (°F)	
	1695	1905
500	52	54.5
600	52	55
700	52	55.5
800	52.5	56.5
900	53	57
950	52	56.5
1000	48	52.5
1100	36.5	42
1200	31.5	35
1300	29	30.5
1400	28	29

**Process Anneal:** Heat at 1245 to 1400° F. Time at temperature depends on size of work. Air cool.

**Hardening:** Preheat at 1400 to 1455° F. Austenitize at 1850 to 1950° F. Quench in oil or air.

**Stabilizing:** Refrigerate at -100 ± 20° F.

**Tempering Recommendations for Parts to be PVD Coated:** Double temper at 950 to 1000° F for high-temperature PVD coatings.

**NOTE:** Data provided is adapted from industrial and technical society sources. Steel producers and suppliers should be contacted directly for more specific information.

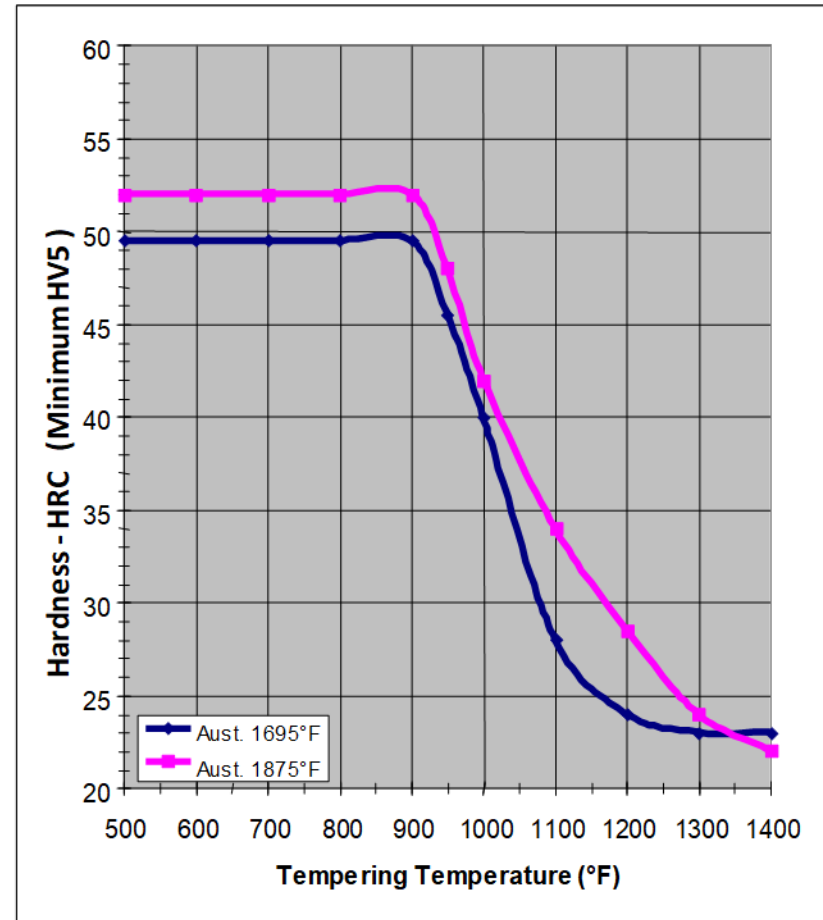


## 420 Martensitic Stainless Steel

Equivalent materials to 420 are:

- AISI420
- AMS 5506
- AMS 5621
- ASTM A276
- ASTM A314
- ASTM A473
- ASTM A580
- DIN 1.4007
- DIN 1.4021
- QQS763
- QQ S766
- UNS S42000

### Hardness vs. Tempering Temperature



### Hardness - HRC

Tempering Temperature (°F)	Austenitizing Temperature (°F)	
	1695	1875
500	49.5	52
600	49.5	52
700	49.5	52
800	49.5	52
900	49.5	52
950	45.5	48
1000	40	42
1100	28	34
1200	24	28.5
1300	23	24
1400	23	22

**Process Anneal:** Heat at 1245 to 1400 ° F. Time at temperature depends on size of work. Air cool.

**Hardening:** Preheat at 1400 to 1455° F. Austenitize at 1795 to 1950° F. Quench in oil or air.

**Stabilizing:** Refrigerate at -100 ± 20° F.

**Tempering Recommendations for Parts to be PVD Coated:**  
Double temper at 950 to 1000° F for high-temperature PVD coatings.



## 416 Martensitic Stainless Steel

Equivalent materials to 416 are:

AISI416

AMS 5610

ASTM A194 (416, 6F)

ASTM A314

ASTM A473

ASTM A581

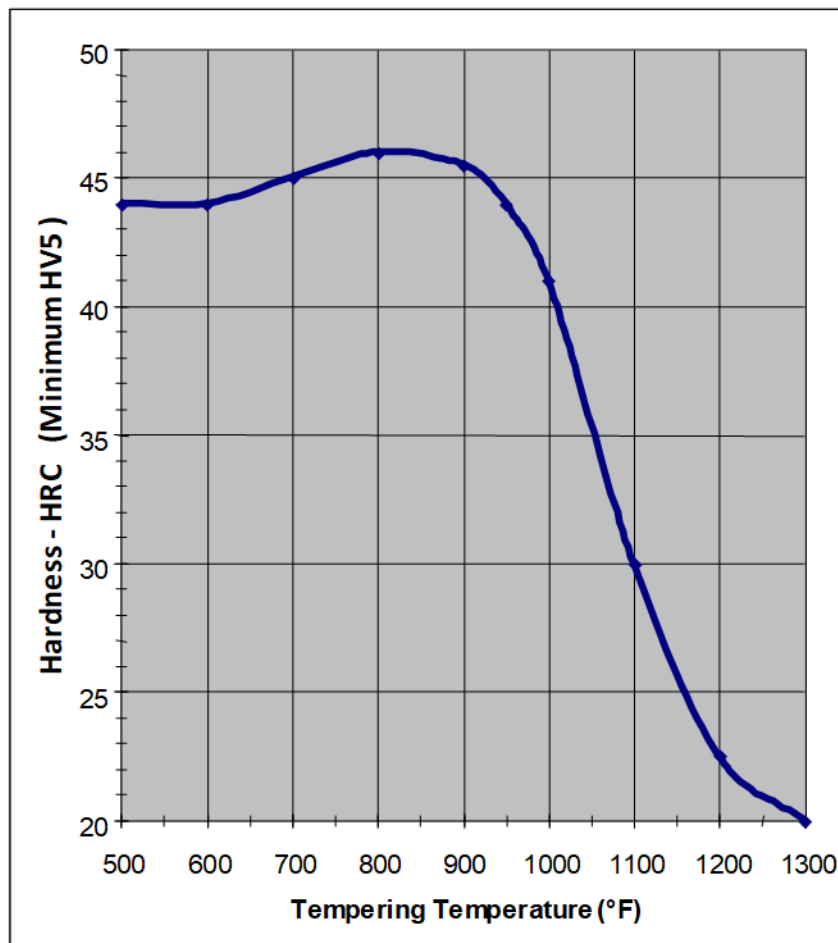
ASTM A582

ASTM A895

DIN 1.4005

UNS S41600

### Hardness vs. Tempering Temperature



### Hardness - HRC

Tempering Temperature (°F)	Austenitizing Temperature 1795° F
500	44
600	44
700	45
800	46
900	45.5
950	44
1000	41
1100	30
1200	22.5
1300	20

**Process Anneal:** Heat at 1200 to 1400 ° F. Time at temperature depends on size of work. Air cool.

**Hardening:** Preheat at 1400 to 1455° F. Austenitize at 1695 to 1850° F. Quench in oil.

**Stabilizing:** Refrigerate at -105 to -320° F.

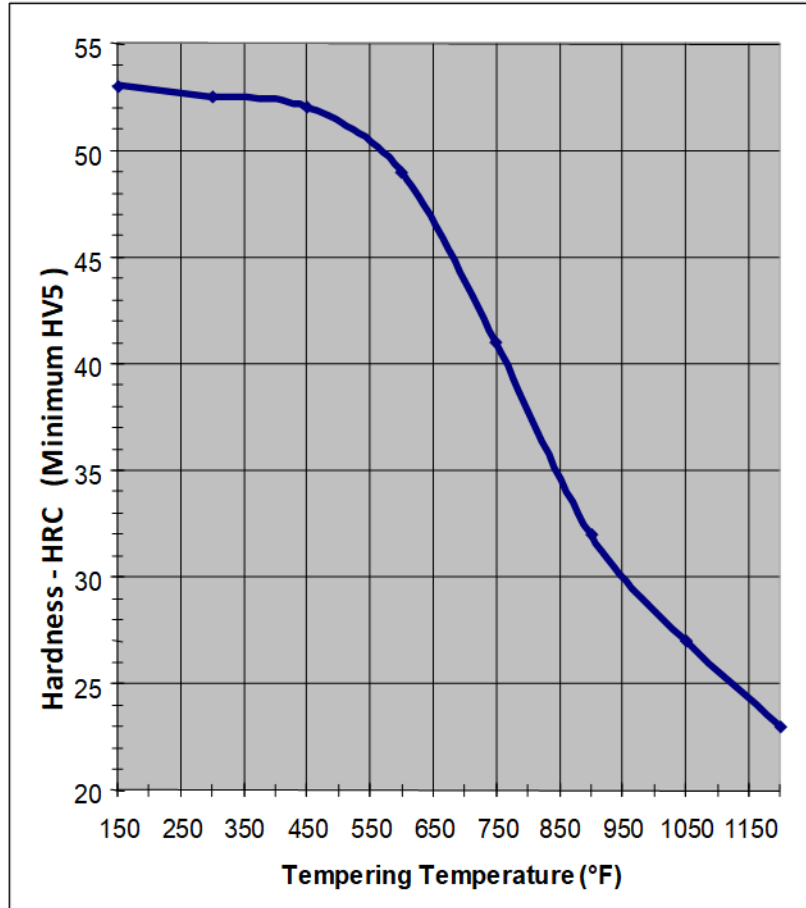
**Tempering Recommendations for Parts to be PVD Coated:**  
Double temper at 950 to 1000° F for high-temperature PVD coatings.

## 4140 Alloy Steel

Equivalent materials to 4140 steel are:

AIS 4140	ASTM A513 (4140)
AMS 6349	ASTM A519 (4140)
AMS 6381	ASTM A646 (4140)
AMS 6382	ASTM A711
AMS 6390	ASTM A752 (4140)
AMS 6395	ASTM A829
AMS 6529	SAE J1397 (4140)
ASTM A193 (B7, B7M)	SAE J404 (4140)
ASTM A194 (7, 7M)	SAE J412 (4140)
ASTM A29 (4140)	UNS G41400
ASTM A320 (L7, L7M, L7D)	
ASTM A322 (4140)	
ASTM A331 (4140)	
ASTM A506 (4140)	

Hardness vs. Tempering Temperature



Hardness - HRC\*

Tempering Temperature (°F)	Austenitizing Temperature 1570°F
150	53
300	52.5
450	52
600	49
750	41
900	32
1050	27
1200	23

\*Averages based on fully quenched structures

**Normalizing:**

Heat to 1555 to 1650° F.  
Air cool.

**Annealing:**

Can be performed to achieve either a pearlitic or spheroidized structure. Follow steel supplier recommendations.

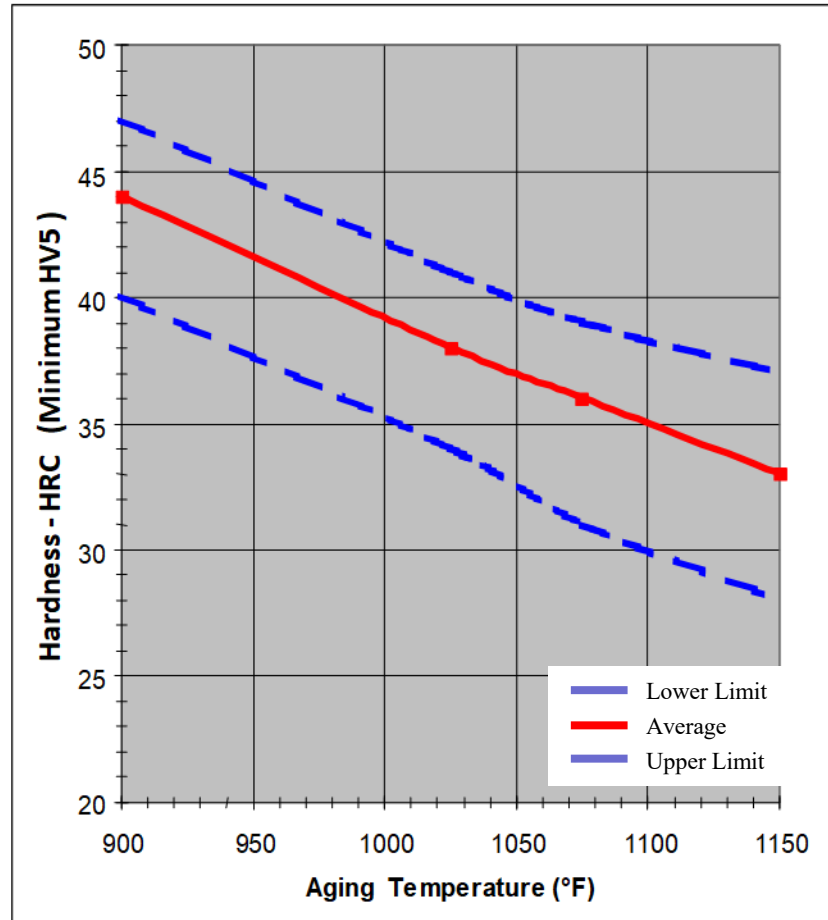
**Hardening:**

Austenitize at 1525 to 1600° F.  
Oil Quench.

**Tempering Recommendations for Parts to be PVD Coated:**  
Temper at 950 to 1000° F for high-temperature PVD coatings.

# 17-4PH Cast PH Stainless Steel

Hardness vs. Aging Temperature



Hardness - HRC

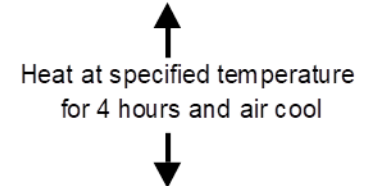
Aging Temperature (°F)	Lower Limit*	Average	Upper Limit*
900	40	44	47
950	37	41	44
1000	36	38	43
1025	34	38	41
1050	32	36	38
1075	31	36	38
1100	30	33	37
1150	28	33	37

\*Upper and lower limits are offered as guidelines

Equivalent materials to 17-4p are:  
 ASTM A693 grade 630 (AMS 5604B)  
 UNS S17400  
 EURONORM 1.4542  
 X5CrNiCuNb 16-4  
 AFNOR Z5 CNU 17-4PH  
 DIN 1.4542

**Condition H900:** Heat at 900° F for 1 hour and air cool.

**Conditions H925:**  
**Conditions H1025:**  
**Conditions H1075:**  
**Conditions H1100:**  
**Conditions H1150:**



**Aging Recommendations for Parts to be PVD Coated:**  
 Age at 950 to 1000° F for high-temperature PVD coatings.

NOTE: Data provided is adapted from industrial and technical society sources. Steel producers and suppliers should be contacted directly for more specific information.

## S7 Shock-Resisting Tool Steel

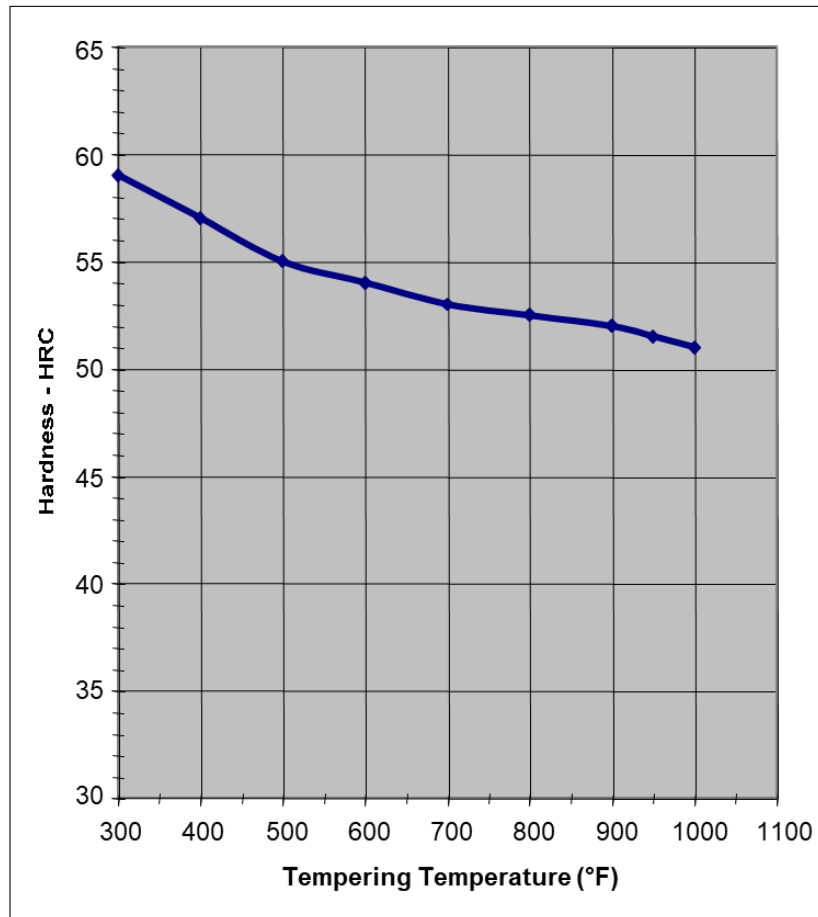
Equivalent materials to S7 steel are:

ASTM A597 (CS-&)

ASTM A681 (S-7)

UNS T41907

Hardness vs. Tempering Temperature



Hardness - HRC

Tempering Temperature (°F)	Austenitizing Temperature (°F) 1725°F
300	59
400	57
500	55
600	54
700	53
800	52.5
900	52
950	51.5
1000	51

**Stress Relieving:** Heat to 1200 to 1245° F and hold for 1 hour per inch of cross section. Air cool.

**Hardening:** Preheat at 1200 to 1300° F. Austenitize at 1695 to 1750° F. Quench in oil or air cool.

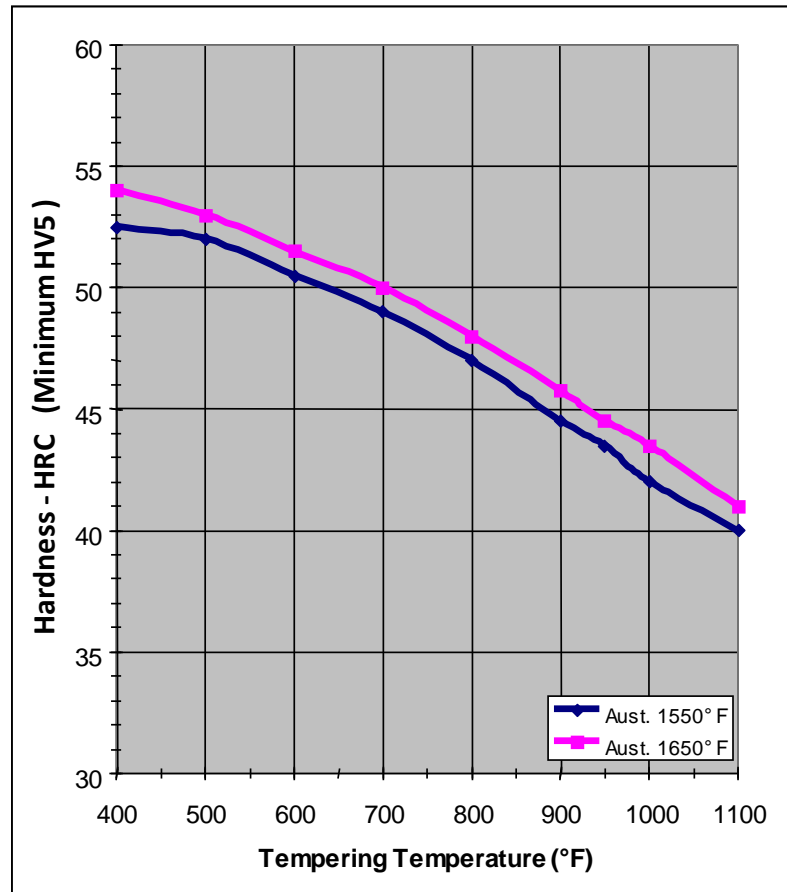
**Stabilizing:** Stress relieve temper at 300 to 320° F. Refrigerate at -150 to -320° F.

**Tempering Recommendations for Parts to be PVD Coated:** Temper between **950 and 1000° F**. For intricate shapes, stabilize prior to tempering.

## P20 Mold Series

Equivalent materials to P20 steel are:  
 ASTM A681  
 UNS T51620

### Hardness vs. Tempering Temperature



### Hardness - HRC

Tempering Temperature (°F)	Austenitizing Temperature (°F)	
	1550	1650
400	52.5	54
500	52	53
600	50.5	51.5
700	49	50
800	47	48
900	44.5	45.75
950	43.5	44.5
1000	42	43.5
1100	40	41

**Stress Relieving:** Preheat at 1200 to 1245° F for 1 hour per inch or cross section. Air cool.

**Hardening:** Austenitize at 1500 to 1600° F. Oil quench.

**Tempering Recommendations for Parts to be PVD Coated:** Temper at 950 to 1000° F.

**NOTE:** Data provided is adapted from industrial and technical society sources. Steel producers and suppliers should be contacted directly for more specific information.

## H13 Hot Work Tool Steel

Equivalent materials to H11 are:

DIN 1.2344

AMS 6408

ASTM A681 (H-13)

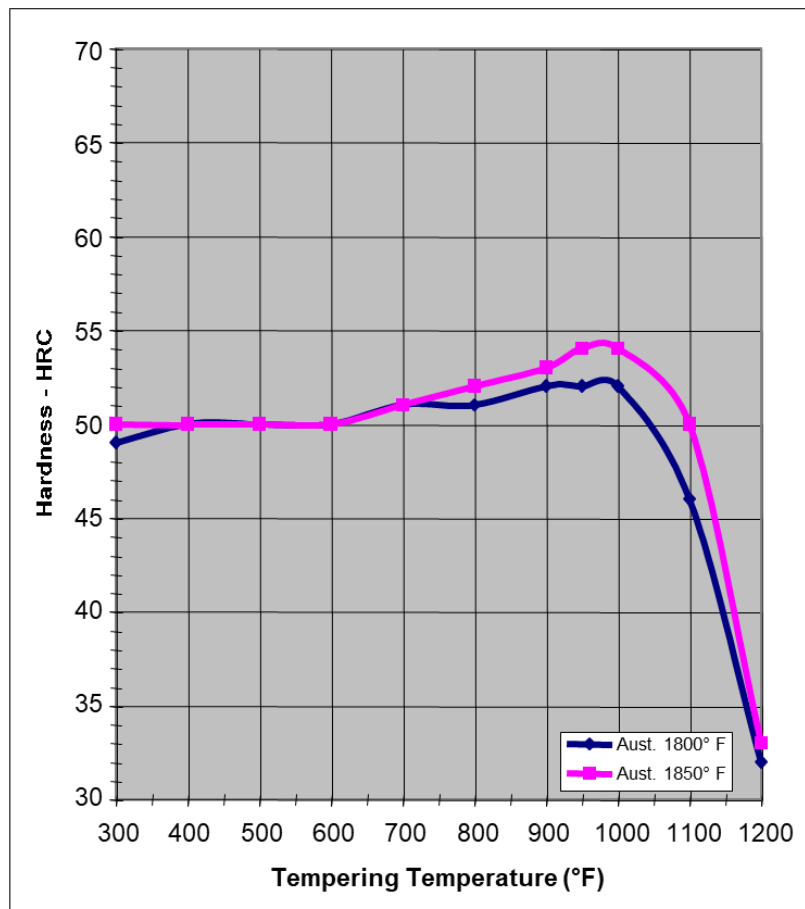
SAE J437 (H13)

SAE J438 (H13)

SAE J467 (H13)

UNS T20813

Hardness vs. Tempering Temperature



Hardness - HRC

Tempering Temperature (°F)	Austenitizing Temperature (°F)	
	1800	1850
300	49	50
400	50	50
500	50	50
600	50	50
700	51	51
800	51	52
900	52	53
950	52	54
1000	52	54
1100	46	50
1200	32	33

**Stress Relieving:** Heat to 1200 to 1245° F and hold for 1 hour per inch of cross section. Air cool.

**Hardening:** Preheat at 1350 TO 1400° F. Austenitize at 1825 to 1905° F. Quench in salt and/or air.

**Stabilizing:** Stress relieve temper at 300 to 320° F. Refrigerate at -150 to -320° F.

**Tempering Recommendations for Parts to be PVD Coated:** Double or triple temper at 1000° F. Intricate shapes can be stabilized prior to tempering.



## A2 Medium Alloy, Air Hardening Cold Work Tool Steel

Equivalent materials to A2 are:

ASTM A681 (A-2)

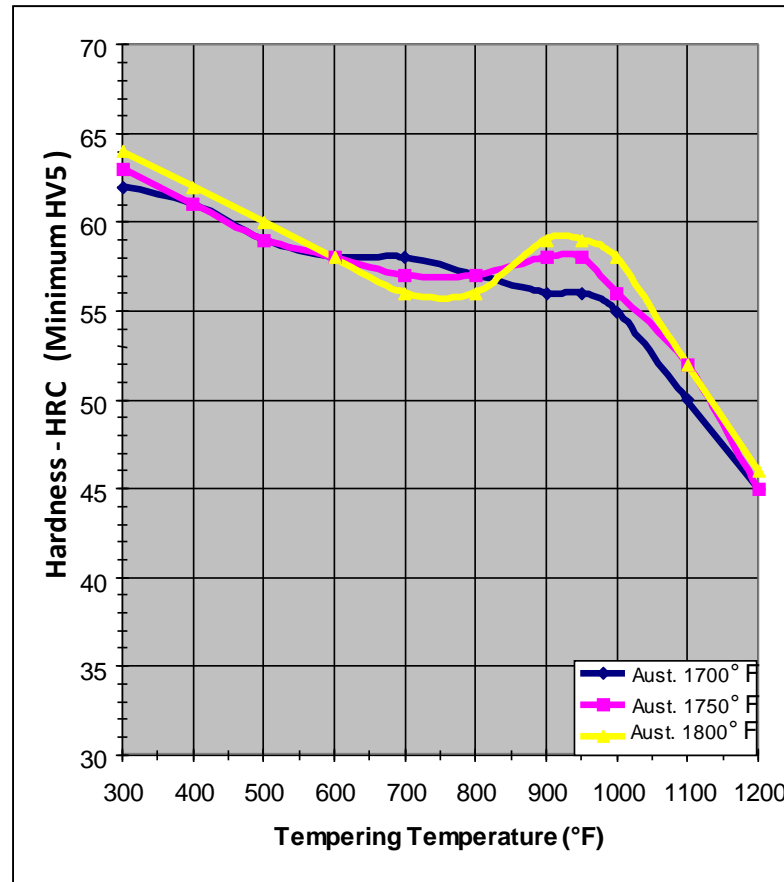
DIN 1.2363

SAE J437 (A2)

SAE J438 (A2)

UNS T30102

### Hardness vs. Tempering Temperature



### Hardness - HRC

Tempering Temperature (°F)	Austenitizing Temperature (°F)		
	1700	1750	1800
300	62	63	64
400	61	61	62
500	59	59	60
600	58	58	58
700	58	57	56
800	57	57	56
900	56	58	59
950	56	58	59
1000	55	56	58
1100	50	52	52
1200	45	45	46

**Stress Relieving:** Heat to 1200 to 1245° F and hold for 1 hour per inch of cross section. Air cool.

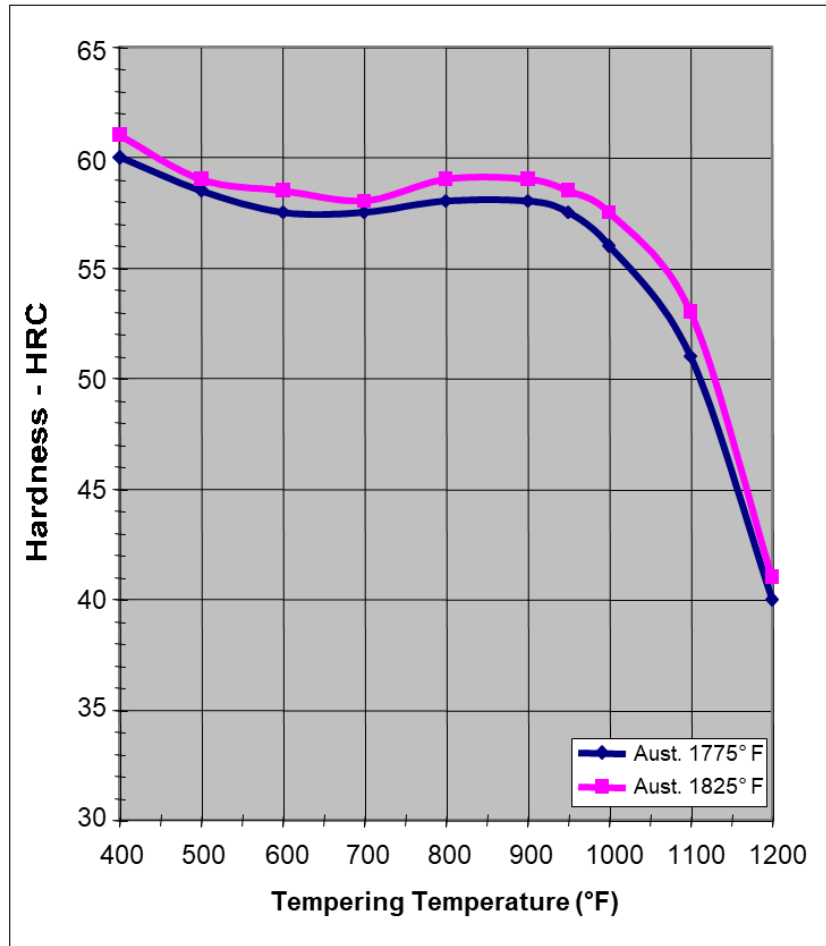
**Hardening:** Preheat at 1455° F and austenitize at 1695 to 1795° F. Air cool.

**Stabilizing:** Stress relieve temper at 300 to 320° F. Refrigerate at -120° F.

**Tempering Recommendations for Parts to be PVD Coated:** Double temper between 950 and 1000° F. Stabilize prior to tempering to improve dimensional stability.

## D2 High-Carbon, High-Chromium Cold Work Tool Steel

Hardness vs. Tempering Temperature



Hardness - HRC

Tempering Temperature (°F)	Austenitizing Temperature (°F)	
	1775	1825
400	60	61
500	58.5	59
600	57.5	58.5
700	57.5	58
800	58	59
900	58	59
950	57.5	58.5
1000	56	57.5
1100	51	53
1200	40	41

Equivalent materials to D2 are:  
 ASTM A681 (D-2)  
 DIN 1.2379  
 SAE J437  
 SAE J438

- Stress Relieving:** Heat to 1245 to 1300° F and hold for 1 hour per inch of cross section. Air cool.
- Hardening:** Heat slowly. Preheat at 1500° F and austenitize at 1795 to 1875° F. Quench in air. When salt quenching, quench in salt bath at 1000° F.
- Stabilizing:** Stress relieve temper at 300 to 320° F. Refrigerate at -120° F.

**Tempering Recommendations for Parts to be PVD Coated:** Double temper at 1000° F. Intricate shapes can be stabilized prior to tempering.